3.2 Kustgebieden

https://student.lessonup.com/lesson/ZzEHikw7qRqiDJfpm

layer	density / g cm^{-3}
continental crust	2.7–3.0
sediments on continental shelf	2.4
oceanic crust	3.0–3.3
mantle	3.3–5.7

Table 6.1. Densities of the Earth's rock layers.

During the last ice age, much of the planet's ocean water was frozen as ice, lowering sea-levels worldwide. These lower sea-levels meant that most, if not all, of the continental shelf regions were above water at the time. Now that these areas are back under water, they form the base of shallow seas at the outermost edge of continents. Remember, the continental shelf is a relatively shallow area of the ocean covered in sediments as a result of the erosion of rocks on the continents. The depth of water in these areas is controlled by two factors:

- changes in sea-level as a result of the melting or freezing of sea ice
- changes in land height as a result of isostatic changes.

SELF-ASSESSMENT QUESTIONS

7 Would you expect the continental shelf near a convergent plate to be wide or narrow? Why?

8 How does isostasy create shallow seas during non-ice age time periods?

6.7 The littoral zone

The area of the ocean most commonly studied is that of the **littoral zone**. This is the area of the shore where land meets sea and is also known as the intertidal zone. The littoral zone is the area between the high water mark during spring tides and the lowest part of the shore that is permanently submerged. This area of the ocean is varied and is categorised according to:

- the shape of the shore
- wave action and erosion
- the substrate that makes up the shore
- the organisms that live there.

KEY TERMS

Littoral zone: the benthic, or bottom, zone between the highest and lowest spring tide shorelines, also referred to as the intertidal zone

Morphology: the study of the forms of things

Morphology of the littoral zone

The shape of the sea shore depends primarily on the geology of the land lying closest to the shore and the level of exposure to erosion on that shore. This means that sea shores may be nearly flat areas covered in fine particles of mud or nearly vertical areas with large rocks. Scientists studying the different shape and make-up of sea shores are studying the **morphology** of that shore. The two factors that scientists focus on when studying morphology are the slope of the shore and the size of the sediment found on the shore. Table 6.2 shows some different categories and diameters of sediments commonly found on sea shores.

particle type	diameter / mm
silt	0.002–0.02
fine sand	0.02–0.2
coarse sand	0.2–2.0
gravel (small stones)	>2.0

Table 6.2. Diameters of common sediment types.

Rocky shores

Rocky shores are areas of shore that are characterised by the presence of a rocky substrate (Figure 6.10). Rocky shores vary widely in slope from nearly vertical cliff faces to wide flat expanses of rocks. The size of the rocks making up the shore also varies from very large boulders to much smaller pieces of gravel and pebbles.

Figure 6.10. A rocky shore with tide pools in Cozumel, Mexico

Geologically speaking, rocky shores tend to be made of primarily granite or igneous rocks, which are incredibly resistant to weathering and take a much longer time to break down than softer rocks such as sandstone. Rocks along these shores often exist in a gradient, with the largest rocks occurring farthest from the water at the high-water mark and the smallest rocks occurring nearer the low-water mark. Scientists believe this gradient is caused by the pounding of waves wearing away those rocks closest to the water line first and not being able to reach those farther up the shore. It is not surprising that these shores are the most resistant to erosion even though they also tend to be the most open and exposed.

Sandy shores

A normal sandy shore is made of loose deposits of sand (silica), small pieces of gravel and shells. Sandy shores are formed by the **erosion** of sandstone and **deposition** of sediments by the waves. Sandy shores are constantly in motion as the ocean moves the sand up and down the beach. These shores tend to have a gradual slope towards the ocean.

KEY TERMS

Erosion: a natural process where material is worn away from the Earth's surface and transported elsewhere

Deposition: a geological process where sediments, soil and rocks are added to a landform or land mass

Muddy shores

Muddy shores are found in protected regions and are shores least exposed to erosion. There tends to be no slope on muddy shores, giving rise to the name mud flat. A lack of erosion and little to no water movement allows the deposition of a layer of very fine silt particles and organic materials.

Estuaries

Estuaries form in sheltered or partially enclosed areas where fresh water and salt water meet; this mix of water is called brackish. Because these areas are sheltered from the erosive action of waves, the bottom is often made of fine sand and silt that falls out of suspension when the water is still. The water in estuaries is very murky, with high turbidity as a result of the fine sediments. Other names for estuaries include bays, lagoons, sounds and sloughs.

KEY TERMS

Estuary: a partially enclosed, tidal, coastal body of water where fresh water from a river meets the salt water of the ocean

Delta: a low-lying triangular area at the mouth of a river formed by the deposition of sediments

Deltas

Deltas form at the mouth of a river where it meets the sea. These shores are named after the Greek letter delta (Δ) because they usually have a triangular shape (Figure 6.11). As a river flows towards its mouth, it picks up sediment along the way. The river begins to widen as it approaches the sea, slowing down the speed of the water. When the water slows enough, the sediments begin to settle on the bottom of the river. Over time, these sediments deposit and accumulate into sandbars and other small landmasses, forming a wide fan-shaped structure resembling a branching tree. If the landmasses build up enough, it is possible for the delta to form new tributary channels of the river. The most well-known river deltas are the:

- Mississippi River Delta, leading to the Gulf of Mexico in the United States
- Nile River Delta, draining into the Mediterranean Sea in Egypt.

Figure 6.11. Nile River Delta.

Ecosystems of the littoral zone

Ocean ecosystems are a product of the environment in which they exist. Many abiotic factors, including temperature, exposure to air, stability of the substrate and salinity, have a role in the formation of an ecosystem. These and others are responsible for the development of the many ecosystem types located within the littoral zone.

This chapter focuses on the formation of the three ecosystems that can develop in the littoral zone of oceans: rocky shores, sandy shores and mangroves.

Rocky shores

Living on a rocky shore is not easy. Organisms have a lot to contend with, including fluctuating temperatures, wave action and exposure to air based on the tides. Other factors that they have to adapt to are the slope of the shore, what type of rocks make up the substrate, whether the habitat is in a temperate or tropical region, and how much sunlight is available at any time during the year. It may therefore come as a surprise to you that rocky shores are typically habitats with significant biodiversity (Figure 6.12).

In spite of the difficulties organisms may face living on a rocky shore, these areas provide habitat and stability to a multitude of species within the littoral zone. The rocky substrate provides many places for organisms to attach to, a necessity for survival in a place where waves can wash organisms and substrate away. Algae, barnacles, sea anemones and many species of mollusc make their home attached to the rocky surface. The need for safe anchorage makes space, not food or light, the main resource that organisms compete for in this ecosystem.

In order to reduce competition for space, species in rocky shore ecosystems space themselves vertically on the rocks in a pattern called **zonation**. To determine the upper limit of a species' zone, scientists look for physical factors affecting survival: temperature tolerance and length of time the species can spend out of water before **desiccation**. To find the lower level of a species' zone, scientists look at biological factors: competition between other species and predation. The intertidal zone on a rocky shore can be divided into three major areas (Figure 6.13).

Figure 6.12. Rocky shore flora and fauna at Cannon Beach, Oregon.

KEY TERMS

Zonation: a separation of organisms in a habitat into definite zones or bands according to biological and physical factors, common in rocky shore habitats

Desiccation: the process of drying out or losing moisture

- High-tide zone: this area only has water during high tides. Organisms here must be able to withstand long periods of time without water or food. These organisms risk desiccation or drying out. Typical organisms located in this zone include chitons, crabs, isopods and barnacles.
- Middle-tide zone: this area is exposed to air twice a day at low tide, so organisms must have a coping method to deal with desiccation. Typical organisms in this zone include limpets, periwinkles and mussels.
- Low-tide zone: this area is usually covered with water, except during the lowest spring tides (Chapter 7). Organisms found here have very few adaptations for living outside water and dry out or overheat easily. Typical organisms found here include seaweed, algae, sea stars, sea urchins, sea anemones and oysters.

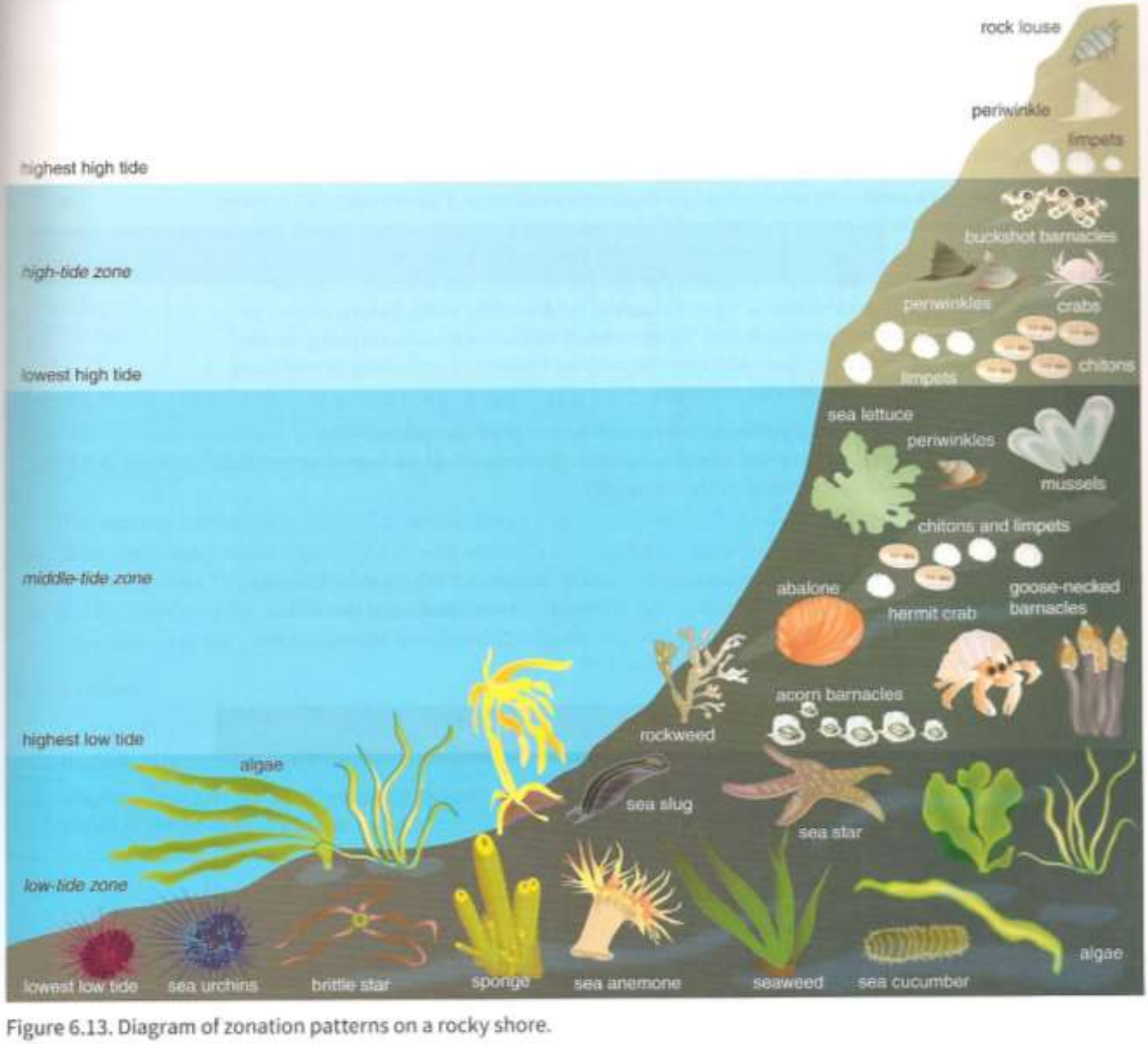

Figure 6.13. Diagram of zonation patterns on a rocky shore.

Within each of these zones, tide pools may exist. Tide pools form when seawater fills a particularly low spot in the rocks during low tides (Figure 6.10). Tide pools are important for organisms in the higher zones to survive because they create an area where they can cool down, carry out gaseous exchange and feed. As the tide comes back in, the water in the tide pool is replaced and refreshed so there are few problems with increased salinity or decreased oxygen.

Sandy shores

Sandy shores produce a unique set of circumstances for organisms to deal with. The most difficult factor organisms have to be adapted for is the ever-shifting substrate. Sandy shores are incredibly unstable, as a single wave or gust of wind can remove a lot of the fine sand the organisms live on. Most organisms therefore deal with this situation by living *in* the substrate rather than *on* the substrate. Organisms found on a sandy shore tend to be burrowers or **infauna**, such as ghost crabs, cockles and other bivalves, and annelid worms like ragworms and lugworms. These challenges explain why sandy shores tend to have low biodiversity compared to rocky shores.

KEY TERM

Infauna: animals living within the sediments of the ocean floor, river or lake beds

Organisms on a sandy shore also show vertical zonation patterns similar to those on a rocky shore (Figure 6.14). Once again, the area inhabited by an organism is determined by both physical and biological factors, such as predation and the ability to resist drying out. The primary difference between zonation on rocky shores and sandy shores is that it is less noticeable on sandy shores because of the burrowing nature of the organisms that live here.

Because there is no place for attachment on a sandy shore, seaweeds cannot survive here. The only producers that may occur on a sandy shore are phytoplankton brought in by the tides. Therefore most of the organisms on sandy shores are detritivores that collect organic material from between sand grains as they burrow. This is particularly the case on coasts where sand is mixed with muddy deposits. However, a sand and mud shore is more stable than a shore of sand alone, so more biodiversity is present.

Mangroves

Mangroves are trees that prefer to live in coastal or estuarine environments between latitudes 25 °N and 25 °S. There are more than 110 species of mangrove, many of which are found in Indonesia where mangrove biodiversity is highest. These trees survive in saline habitats because of the lack of competition from other plants. Mangroves tend to form woodland habitats that provide the basis for incredibly biodiverse habitats. Areas where mangroves grow are referred to as mangrove swamps, mangrove forests or just mangroves.

Within a coastal or estuarine habitat, there are two primary physical factors that mangroves have to contend with that can impact their survival:

- high salt content in the water
- low oxygen content in the substrate.

High salt content

Mangroves have several adaptations for dealing with the high salt content of coastal and estuarine waters. Red mangroves (*Rhizophora mangle*) have two methods for living in salt water. The first method begins at the roots, which have become nearly impermeable to salt because

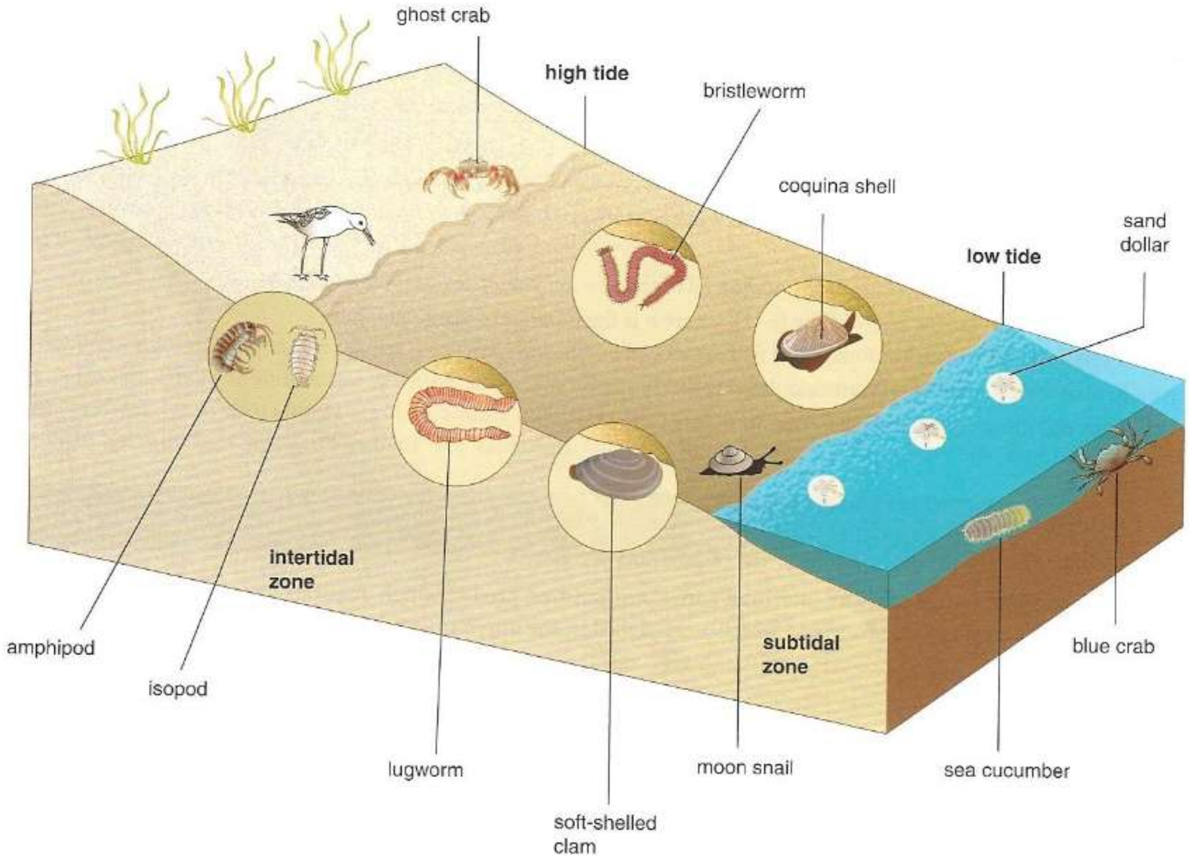

Figure 6.14. Common zonation patterns on a sandy shore.

of a very efficient filtration method. Some scientists have hypothesised the use of a 'sacrificial leaf', where red mangroves deposit excess salts that make it past the filtration system. However, other studies dispute this hypothesis. Black mangroves (*Avicennia germinans*) expel salt through pores on the underside of their leaves.

Anoxic soil

Red mangroves use prop roots to hold themselves above the water level at high tide and absorb the oxygen they need through their bark. Black mangroves do not possess prop roots. Instead their roots are specially designed with pneumatophores that act as snorkels and stick up out of the water. These pneumatophores allow the roots of the tree to breathe even during high tides (Figure 6.15).

Figure 6.15. Black mangrove (*Avicennia germinans*) tree with pneumatophores protruding from the water at high tide.

The root systems of red mangroves are called prop roots because they primarily exist above the substrate and prop up the tree. The unusual design of prop roots allows them to have a specific function in this ecosystem as well as serve the traditional purpose of tree roots (Figure 6.16). Prop roots help prevent erosion by storms such as hurricanes and reduce wave energy, similar to a coral reef. This feature of mangroves is why they are protected in Florida in the United States and why they are being replanted in many places in Indonesia. Because these roots provide a cage-like structure under the water at high tide and collect sediment, many organisms find a home among the roots. Algae, oysters, sponges, crabs, barnacles, fish and other crustaceans all live among mangrove roots, making mangrove a keystone species in this environment.

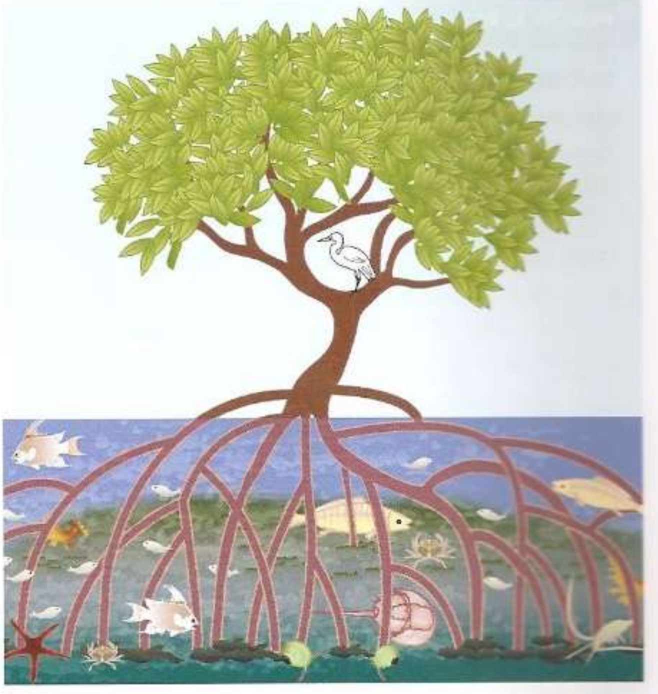

Figure 6.16. Illustration of red mangrove (*Rhizophora mangle*) showing how the prop roots retain sediments and act as a habitat for local species.

The extensive root system also makes mangroves unique in their ability to grow their own habitat. When a mangrove tree produces seeds, or propagules, they float around in the ocean for a period of time (each species requires a specific length of time). Eventually, the propagule will come to rest on a piece of land and begin to root. In some cases the 'land' is just a sand bar or area of high **sedimentation**. Once the propagule takes root, a new mangrove tree begins to form. The roots of the newly formed tree begin to act as a trap for sediment and slowly build an island as more mangrove colonise the trapped sediment.

KEY TERM

Sedimentation: the act or process of depositing sediment from a solution (e.g. seawater)

SELF-ASSESSMENT QUESTIONS

9 What is the primary difference between an estuary and a delta?

10 Why are rocky shores able to house more biodiversity than sandy shores?

11 How do the roots of the red mangrove work to create an ecosystem?

Opdracht bij les 3.2

- Case study: ‘De voordelen van mangroven’

Les 3.2 - De voordelen van mangroven

Mangroven worden gevonden in tropische en subtropische gebieden rond de wereld. Verschillende soorten mangroven leven in een typisch mangrove moeras, afhankelijk van de tolerantie van iedere soort voor de saliniteit en het lage zuurstofgehalte van de bodem. De soorten die de meeste tijd onder water kunnen doorbrengen, en met de hoogste tolerantie voor saliniteit, zullen het best groeien vlak bij de zee. De andere soorten zullen groeien in gebieden verder bij de kust vandaan afhankelijk van hun tolerantie.

Er zijn verschillende ecologische en financiële voordelen aan mangroven. Ze werken als een buffer voor kustgebieden tegen tropische stormen door een golfbreker te creëren. De wortels van de mangroven het dichtst bij de kust, helpen erosie te voorkomen door het sediment vast te houden. Mangroven zijn ook een natuurlijke manier om klimaatsverandering tegen te gaan. Ze absorberen koolstofdioxide en slaan dit op in hun wortels. Mangrovebossen in Indonesië bevatten meer dan 3 miljard metrische tonnen koolstof in de bomen, bodem, wortels en takken.

Het grootste mangrovebos ter wereld, bijna 3 miljoen hectare, is te vinden in Indonesië. Sinds 1980 is Indonesië bijna 40% van het mangrovebos verloren. Het is daarmee het land dat het snelst mangrovebos vernietigt ter wereld. Hierdoor is het ook verantwoordelijk voor 42% van de koolstofdioxide die jaarlijks vrijkomt door het vernietigen van kustecosystemen. Oorzaken voor het vernietigen van mangroven zijn de boomkap, gebruiken van land voor landbouw en vervuiling. In Azië is de belangrijkste oorzaak de aquacultuur, en dan vooral het kweken van garnalen. Tussen 1988 en 2008 is de productie van garnalen van deze kwekerijen gestegen van 500.000 metrische ton naar 2,8 miljoen metrische ton. Hiervoor zijn grote stukken mangrovebossen vernietigd.

Gelukkig zijn veel overheden tot de conclusie gekomen dat mangrovebossen ook financieel belangrijk zijn. De bescherming van de kust, ontstaan van nieuw land en de kweekkamer voor jonge vissen hebben allemaal financiële waarde. Herbebossing is ook belangrijk om de landen te beschermen tegen het stijgende zeeniveau en tropische stormen. In veel landen is de herbebossing succesvol en wordt de lokale bevolking aangemoedigd om mangroven te planten om de visserij en het toerisme te bevorderen.

1. Leg uit op welke manier mangrovebossen klimaatsverandering afremmen.

2. Bereken het verschil in de sociale en economische waarde van mangrovebossen en garnalenkwekerijen.

3. Stel je voor dat je een voor conservatie organisatie werkt en de lokale overheid moet overtuigen van het planten van een mangrovebos. Leg uit waarom een mangrovebos beter is voor de economie dan een garnalenkwekerij.